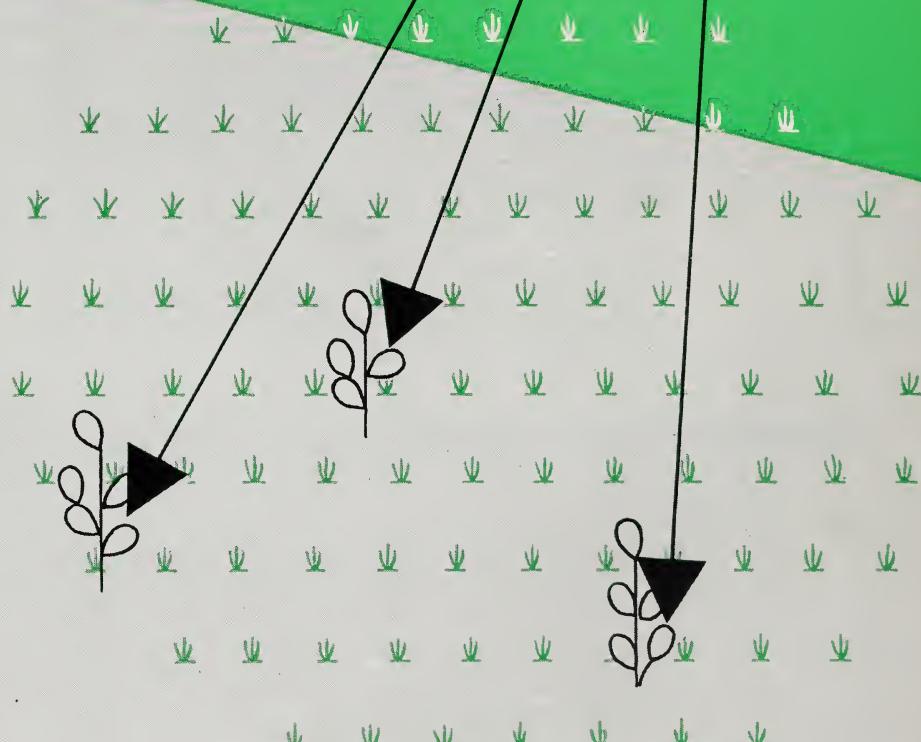


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SELECTIVE WEED KILLERS

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THE COLLEGE OF AGRICULTURE
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CHEMICAL WEED KILLERS

fall into two main classes: **general-contact** and **selective**.



SELECTIVE herbicides are chemicals that kill weeds but do not injure crop plants.



GENERAL-CONTACT weed killers destroy all kinds of vegetation, both weeds and crops. Of course, any chemical, if applied in sufficient quantity, will kill all vegetation. In other words, selective sprays might become general-contact weed killers if improperly used. And general-contact weed killers may be used selectively under certain carefully controlled conditions (see p. 12). (For complete discussion, see California Agricultural Extension Circular 137, "General-Contact Weed Killers.")

Experiments over the past ten years have shown that certain organic compounds make good selective herbicides, and these materials are now replacing the iron and copper salts and strong acids formerly used. This circular discusses the most important of the compounds, which include: dinitro selectives; selective oils; 2,4-D; 2,4,5-T; pentachlorophenol and its salts; I.P.C.; T.C.A.; phenyl mercuric acetate; potassium cyanate; and others.

Certain refined oils have proved successful as selective sprays in carrots and related crops. (See California Agricultural Extension Circular 133, "Oil Sprays for Weeding Carrots and Related Crops.")

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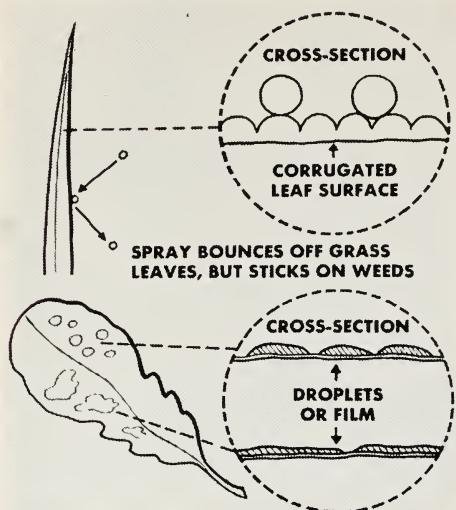
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Coöperative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture coöperating.

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J. Earl Coke, Director, California Agricultural Extension Service.

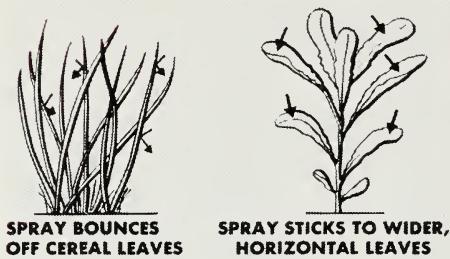
How selective weed killers work



1. Differential wetting

Some plants, such as cereals, have waxy leaf surfaces that are corrugated or formed of very small ridges. Water solutions can stick to only a small portion of these surfaces. When water sprays hit cereal leaves, they bounce off in droplets or wet the surface only in small spots.

Broad-leaved plants have smooth leaf surfaces which are more easily wet by water sprays. When broad-leaved weeds, such as wild mustard, radish, or fiddle-neck, are sprayed with water solutions, the spray tends either to spread as a thin film or to remain as many small droplets that wet a fairly large proportion of the leaf surface.



2. Arrangement and angle of leaves

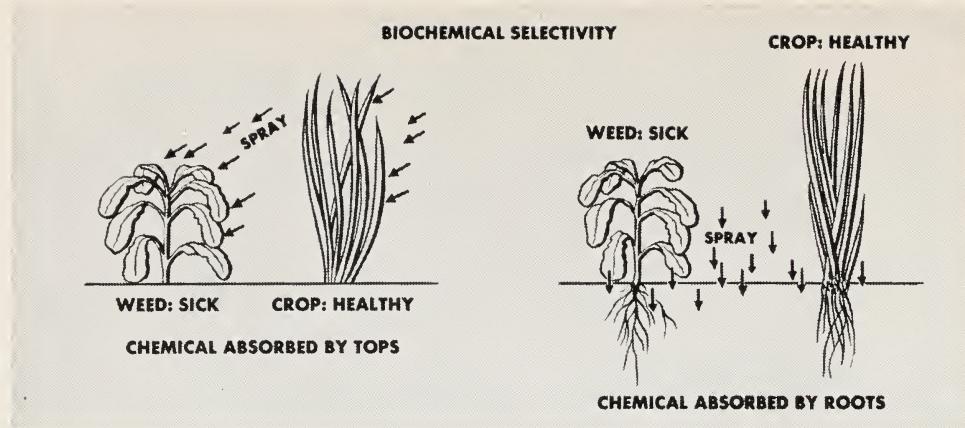
Leaves of cereals are narrow, and stand upright, so that droplets of spray roll off them. Leaves of weeds are wider, and grow out horizontally from the plant stem so that spray spreads over them and sticks—another example of differential wetting.



3. Location of growing points

The growing points of cereals are located in the crown of the plant, below the soil level, and are protected by surrounding leaves. Because of this, any spray which sticks to cereals may injure the upper leaves, but will not reach the growing points and kill the plants.

Broad-leaved weeds, however, have exposed growing points at the tips of the shoots and in the leaf axils. These plants are easily killed by toxic sprays.

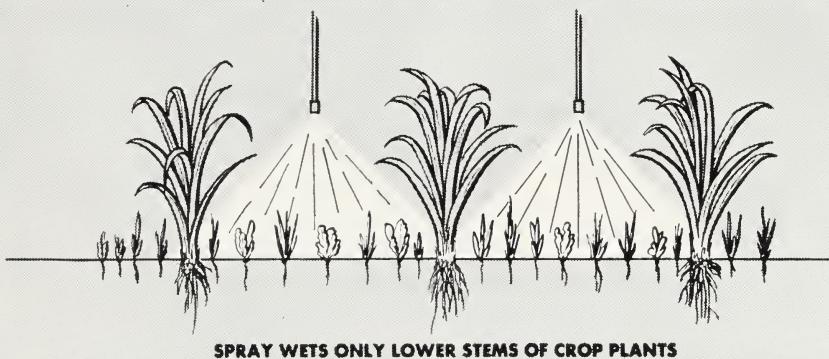


4. Differences in plant tolerance to toxic chemicals.

Some plant cells tolerate the toxic action of certain chemicals better than do others. For example, 2,4-D applied in a nontoxic oil or as a dust will kill weeds such as mustards, radish, or fiddleneck, in cereals, and leave the cereals unharmed. This is biochemical selectivity. Weed sprays having this type of selectivity may be used with success in fields where the

weeds are susceptible to the toxic action of the spray while the crop plants are not damaged.

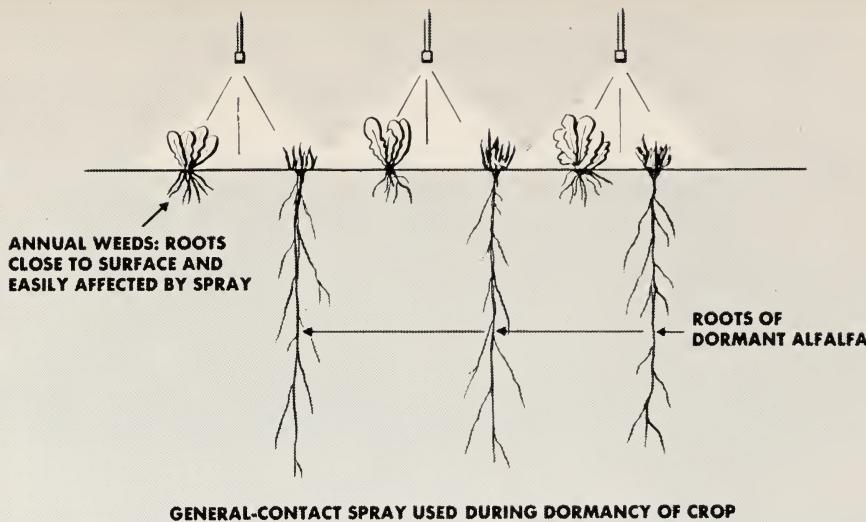
Biochemical selectivity operates in the root systems as well as the foliage of plants. This makes it possible to kill young seedlings of crabgrass and watergrass in corn and milo by spraying 2,4-D on the soil just after the crop has been planted. The weeds will die, but the crop roots will tolerate the chemical.



5. Selective spray placement

It is possible to kill small, tender weeds and vigorous grasses in corn, milo, large onions, and garlic where these plants are well developed, by applying a general-contact spray carefully so that it covers the weeds, but touches only the lower stems of the crop plants. These lower stems are protected by older leaves and

are not injured by the spray, but the weeds are killed. In this method of selective spraying, care must be taken not to apply a spray that is too toxic for the crop plants. (Another method of selective weed control is the flaming of young weeds in crops such as cotton and onions, but the flaming must not be prolonged or the crop will be seriously damaged.)



6. Differences in growth habits

Dormancy. Some perennial crops, such as alfalfa, have a dormant period in winter. At that time, it is safe to use a general-contact spray for control of annual weeds. Such a spray used when the alfalfa is in its growing period, however, would injure the crop. It may be used effectively just after a crop has been cut and removed from the field. This is particularly true where alfalfa is to be dehydrated, and is removed immediately after being cut.

Root systems. When annual weeds grow in deep-rooted crops, they may be killed by general-contact sprays. The crops, with perennial root systems, recover.

Normally, contact sprays kill grasses. However, some grass pastures or seed crops are perennials, and will withstand contact sprays used to kill annual weedy grasses.

Aquatic plants. Weeds that grow in water are more susceptible to some chemicals (naphthas, Benoclor) than are land plants. When these chemicals are emulsified in the ditch water, aquatic weeds are killed. Field crops later irrigated with the water may not be injured.

The selective action of all weed killing chemicals is relative. It must be remembered that even when the factors listed above are taken into account, it is still possible to injure crop plants by applying a weed killer that is too toxic for them.

REMEMBER: You will kill both weeds and crop plants if you do not obey the rules. Keep in mind the types of selective action listed above. You may expect trouble

- if
- 1. Wetting of crop plants is increased by adding wetting agents.
 - 2. Spraying is done while crop plants such as onions or peas are wet with dew.
 - 3. Growing regions are reached by penetrating solutions (oils).
 - 4. The toxicity of the material used is higher than the crop plants can tolerate.
 - 5. A general-contact spray is applied so that it gets onto the leaves of the crop.
 - 6. The margin of selectivity is exceeded by using too much chemical, too high spray pressure, wrong timing, or improper application methods.

It is important that the spray operator know the range of selectivity of his material on both the crops and weeds to be sprayed. Too little chemical will not kill the weeds. Too much chemical, or wrong application methods, may not only kill the weeds, but also injure the crop.

When the seedlings of certain weeds, such as knotweed (*Polygonum aviculare*), attain true leaves, they are as difficult to wet as are crop plants. It has been found impossible to kill such weeds in peas, flax, young alfalfa, and other broad-leaved crops where selectivity depends upon differential wetting alone. In such cases, the

weed can be controlled only by spraying while it is in the cotyledon (two-leaf) stage.

All plants are more susceptible to herbicides when in the small seedling stage than when growth is farther advanced. They are also more susceptible during warm, moist weather than they are when it is cold and dry.

In the discussion of selectives which follows, a range of dosage is given for each product. Usually, this range is wide enough to cover varying weather conditions. **For more specific recommendations, see the chart, pages 8-9.**

Dinitro selectives

The greatest use of the dinitro selectives has been to kill wild mustard, radish, fiddleneck, and other broad-leaved weeds in wheat, barley, and oats. With development of 2,4-D, much of this selective control is being done with that material.

The California Experiment Station at Davis has conducted tests on the two main dinitro compounds—sodium dinitro-ortho-cresylate and the ammonium salt of dinitro-ortho-secondary-butyl-phenol. The first is sold under the commercial name Sinox; the second, as Dow Selective and as Sinox W. These and other dinitro selectives may become available under other trade names in the future.

Sinox W and Dow Selective, being liquids, are more convenient to handle than is Sinox, and they are somewhat more selective on weeds in peas, young alfalfa, vetch, and other legumes. These crops seem to have better chemical tolerance for the ammonium dinitro-butyl-phenylate than for the sodium dinitro-cresylate. However, the latter is preferred by some for weed control in flax and onions.

One weakness of the dinitro sprays is the fact that they will not kill weedy grasses. These may, however, be controlled by general-contact and fortified

oil emulsion sprays if the sprays are applied so that leaves of such crops as onions, corn, milo, cotton, etc., are not touched.

Some of the dinitros have been applied on a limited scale as dusts, but such applications seem to be less effective than are sprays.

Sinox. This is a slurry (watery mixture) of sodium dinitro-ortho-cresylate.

Preparation: Dilute the necessary amount of Sinox with water to the total volume required to wet the vegetation—usually 50-120 gallons per acre, depending on the size of the plants. Partially fill the spray tank with water. Add the Sinox. Use an agitator in the tank, as this makes the Sinox mix more rapidly. Add the remainder of the water, with the agitator still running. Then add 3 pounds of either ammonium sulfate or aluminum sulfate for each gallon of Sinox used. Agitate thoroughly, and spray is ready for use.

Dosage: From $\frac{1}{2}$ to $1\frac{1}{2}$ gallons per acre, the exact amount depending upon kind, size, and succulence of the weeds, and upon the difference between the tolerance of the weeds and that of the crop to the toxic action of the chemical.

NOTE: In using Sinox, remember that the chemical in its original container is not completely in solution. Be sure that the container is completely emptied.

Dow Selective and Sinox W. The active ingredient in these preparations is the ammonium salt of dinitro-ortho-secondary-butyl-phenol. Since this chemical is approximately three times as toxic as sodium dinitro cresylate, less is required in the spray mix.

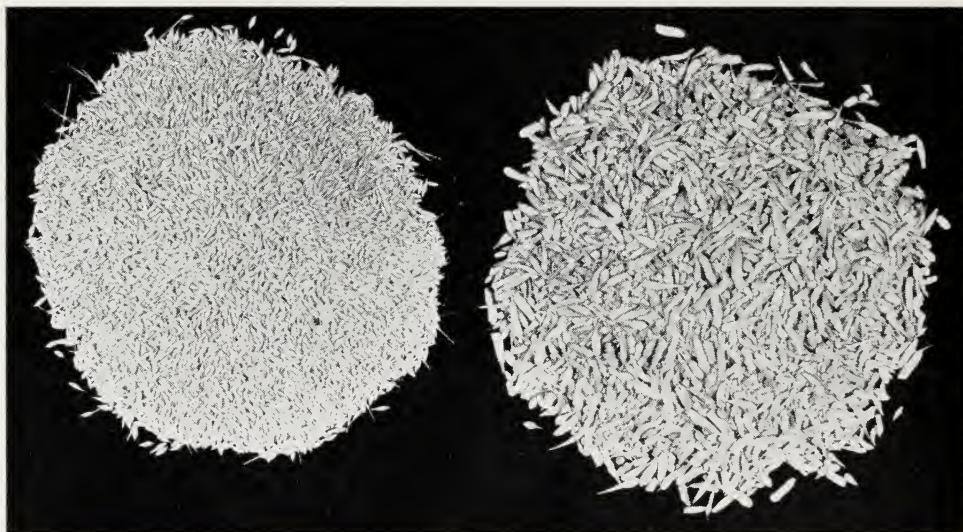
Preparation: Add the concentrate to sufficient water to treat one acre. Since the spray concentrate is in liquid form, only enough agitation to insure a uniform solution is required. If the concentrate is added to the tank during filling, the solution will be ready for use when the tank is full. No ammonium sulfate need be added.

Dosage: From 3 to 6 quarts per acre, the amount depending on the weed and crop growth and the crop's tolerance. During dry, sunny weather, more chemical is required than during cloudy, moist weather.

For airplane application, the common rate is 3 quarts in 15 to 20 gallons of water, per acre. Although this dosage on flax results in slight burning, it is commonly used.

Use of dinitro selectives on peas is becoming standard practice. Application is sometimes made by airplane, but ground-rig application is preferred because its high-volume, low-pressure spray is less injurious to the crop. Temperature is an important factor in spraying peas. Experiments in the Northwest have resulted in the following recommendations for adjusting the dosage: 60°-65° F, 4 quarts; 65°-70° F, 3½ quarts; 70°-75° F, 3 quarts; 75°-80° F, 2½ quarts. These recommendations are for ground-rig application of 100 gallons per acre at 35 to 50 pounds pressure.

For application of dinitros by ground rig, 4 quarts in 50 to 80 gallons of water, per acre, are used. On flax, this usually results in slight burning, but generally gives good weed control. Crop plants growing in alkali soil or poorly drained areas generally suffer more damage than do healthy, vigorous plants.



Left: barley from plot sprayed with Sinox for control of wild radish. Right: barley from unsprayed plot. Note number of radish pods remaining in grain after threshing.

AVERAGE DOSAGE RATES FOR USE OF SELECTIVE SPRAYS

CROP	WEEDS	CHEMICAL AND DOSAGE (Average values per acre)*		VOLUME (Gallons per acre)
		3/4 gallon + water	13 per cent solution,	
ALFALFA—seedling	Pigweed, lamb's quarters, morning-glory	Sinox W or Dow Selective:	1 qt. + 35 gal. Diesel oil	50
ALFALFA—established during winter dormancy	Foxtail, chickweed, shepherd's purse, yellow star thistle	Sinox or Dow General:	1 qt. + 35 gal. Diesel oil + 100 gal. water	135
ALFALFA—established after cutting	Yellow star thistle	Sinox or Dow General:	2 qts. + water	100
BIRDSFOOT TREFOIL	Star thistle, curly dock, plantain, chicory	2,4-D salt:	1/2 lb. acid equivalent + water	100
	Foxtail, ripgut, chess	I.P.C.:	2 lbs. + water	100
CARROTS	Foxtail, annual bluegrass, mustard, radish, shepherd's purse, pigweed	Standard solvent (Shell Weedkiller No. 10, Pentox No. 1)		35
CELERI in beds	Same as for carrots			
CEREALS: wheat, oats, barley, rye—6 inches high	Broad-leaved annuals, mustard, amsinckia, radish	2,4-D salt:	1/2 lb. acid equiv. + water 2,4-D ester:	Low: 5 High: 100
CORN 12 inches high	Pigweed, lamb's quarters, cocklebur, morning-glory, kelp	Sinox W or Dow Selective:	13 per cent solution, 1 gal. + water	100
FLAX 6 inches high	Broad-leaved annuals, mustard, amsinckia, radish	2,4-D salt:	1/4 lb. acid equiv. + water	Low: 15 High: 75
		Sinox:	1 gal. + 3 lbs. ammonium sulfate + water	100

GRASS seed, turf GRASS pasture	Dandelion, plantain, chicory, spurge, and winter annual weeds	2,4-D salt: 1 lb. acid equiv.+ water 2,4-D ester: $\frac{1}{2}$ lb. acid equiv. + water	Low: 10 High: 100
LADINO CLOVER	Star thistle, curly dock, plantain, chicory	2,4-D salt: $\frac{1}{4}$ lb. acid equiv.+ water	100
Foxtail, ripgut, chess	I.P.C.: 2 lbs.+ water	100	
MILLET 6 inches high	Pigweed, lamb's quarters, cocklebur, morning-glory, kelp	2,4-D salt: $\frac{1}{2}$ lb. acid equiv.+ water	Low: 10 High: 100
ONIONS and GARLIC to 6 inches high	Mustard, radish, shepherd's purse, nettle	Simox: 1 gal.+3 lbs. ammonium sulfate+water	100
ONIONS and GARLIC 6-12 inches high		Aero Cyanate: 5 lbs.+ water Aero Cyanate: 10 lbs.+ water	60 60
PASTURES and RANGE land	Poison oak, coyote brush, willows, cottonwoods	2,4-D ester: 1 lb. acid equiv.+ water†	160
PASTURE and ORCHARD	Blackberry, oaks, button-willows	2,4-D+2,4,5-T esters: 50:50 2 lbs. acid equiv.+ water†	160
PEAS 4 inches high	Mustard, pigweed, smartweed, thistles, nightshade	Simox W or Dow Selective: 13 per cent solution, $\frac{1}{2}$ gal.+ water	Low: 15‡ High: 75
RICE	Arrowhead, water plantain, sedges	2,4-D salt: $1\frac{1}{2}$ lbs. acid equiv.+ water	10

* Dosage values given are average. Dosage often varies considerably to meet situations that increase or decrease sensitivity of weeds and crop plants to the chemical. Only local experience under a wide variety of conditions can determine exact dosages to use. Volumes must also be varied to meet conditions, particularly with dinitro and other nontranslocated sprays.

† Adding about 4 gallons of Diesel oil or a miscible summer oil per 100 gallons of spray increases the effectiveness of 2,4-D and 2,4,5-T on brushy species.

‡ Low-volume application not recommended in humid regions.



Left: wheat sprayed with Sinox for control of mustard. Center: unsprayed strip.

Other crops that may be sprayed with dinitro selectives are birdsfoot trefoil (both prostrate and erect), ladino, red, and subterranean clovers, vetch, horsebeans, fenugreek, and bitter clover (*Melilotus indica*). These take about the same dosage as peas and flax. When the weather is cool, dry, and clear, and these crops are hardened to it, dosage may be increased to as much as 5 quarts per acre. This may be necessary in order to kill the weeds.

A new use for the dinitros is in the control of weeds in cover crops, particularly purple vetch in vegetables. This has lowered weeding costs considerably.

CAUTIONS FOR USE OF DINITRO SELECTIVES

1. Do not use dinitro selective sprays on flax and peas when the plants are wet, when the soil surface is wet, or when the

humidity is exceptionally high. Cereals and onions are not seriously affected by moisture conditions.

2. Do not spray in the evening during periods of heavy dew.

3. Do not spray when rain is expected within a few hours.

4. Use only the minimum dosage required to control the majority of the weeds. Sufficient chemical to kill large, resistant weeds will also injure crops.

5. Spray onions only after one or more true leaves are present. Do not spray large onions or garlic after the leaves have bent over. Onions growing on peat or light, sandy soil are more susceptible to injury and should be sprayed with caution during wet weather.

6. Make preliminary trials on any crops with which you have not had experience.

Potassium cyanate

This new selective herbicide is sold under the trade name Aero Cyanate, and has been introduced for the control of weeds in onions. Originally developed in the East, where the dinitro compounds were not sufficiently selective for use on onions, potassium cyanate is replacing sulfuric acid, which has been the principal spray for onion crops. It is somewhat more selective than sulfuric acid, and much less corrosive.

The manufacturers recommend using Aero Cyanate at two different concentrations, depending upon the size of the onions. For small weeds in seedling onions, the recommendation is 5 pounds of chemical in 60 gallons of water, per acre. For onions 6 inches tall or over, 10 pounds in 60 gallons of water, per acre, is recommended.

In the Imperial Valley, all weeds except cheeseweed and watergrass were killed,

in young onions and garlic, by potassium cyanate used at the rate of 12 pounds in 80 gallons of water, per acre. Best results followed application at midday, on young weeds in onions 2 to 3 inches tall. Pressure below 100 pounds was better than high pressure. A wetting agent lowered the selectivity of the spray. Garlic was somewhat more tolerant than were onions.

CAUTIONS FOR USE OF POTASSIUM CYANATE

- 1. This is not a very poisonous compound, but it should be handled with care. Do not leave the solution, or empty containers, where children or pets have access to them.**
- 2. Follow all instructions and precautions printed on the label.**
- 3. Use only at recommended dosage and during suitable weather.**

Oil selectives

Certain refined oils, such as Shell Weedkiller No. 10 and Pentox No. 1, were developed for use as selective sprays on carrots and related crops because stove-oil sprays left an unpleasant flavor and reduced the market value of the crops. These new sprays also have a greater selectivity and higher toxicity than stove oil, so that the dosage may be somewhat reduced.

Another recent development in the use of selective oils has been the field trials of Shell Weedkiller No. 11 for controlling wild oats in flax. The preliminary tests indicated that the method is effective, and large-scale trials followed, in the spring of 1948. These trials showed that sprayed flax averaged 34.1 bushels per acre, whereas unsprayed areas averaged 20.3 bushels. Sprayed flax had an average dockage of 8.1 per cent; unsprayed, of 15.8 per cent.

CAUTIONS FOR USE OF OIL SELECTIVES

- 1. Use only oil having a gravity rating above 38° (A.P.I.) for spraying carrots.**
- 2. Apply just enough to wet the plants.**
- 3. Use stove oil only on young carrots (1 to 4 true leaves). (More refined oils may be used to within 6 weeks of harvest.)**
- 4. Move the spray rig at constant speed and shut off the spray before stopping. Carrots receiving too much stove oil from frequent stopping, must be destroyed.**
- 5. Do not harvest carrots until all oil flavor has disappeared.**
- 6. Celery seedlings may be sprayed with oil, but do not use oil to weed transplanted celery.**
- 7. Stoddard solvent, kerosene, and weed oils oxidize upon standing, and become toxic to crops. Use only fresh oil. Test a small plot if in doubt.**
- 8. Atomized oil is very inflammable. Use extreme care to prevent fires.**

General-contact sprays used as selectives

One weakness of the dinitro selective sprays is that they will not kill weedy grasses. Where grasses occur among other weeds in certain row crops, a general-contact spray may be used selectively (see page 4) as a light application at the base of the plants. This will kill both weeds and grasses. Crops able to tolerate this selective spraying include corn, milo, onions (1 foot high or over), and certain varieties of bushes and nursery stock. Fortified oil emulsion sprays may be used on these crops if the concentration is kept at a minimum and the spray nozzles are kept low and arranged so that the solution touches only the bases of the plants.

Formulas for such sprays are:

I. Diesel oil 10 gal.

Dow General or Sinox

General herbicide . . . 1 pt. to 1 qt.

Water 90 gal.

II. Aromatic distillate . . . 8 gal.

Pentachlorophenol . . . 4 lbs.

Oil-soluble emulsion

stabilizer 4 lbs.

Water 92 gal.

For formula I, an agitator is necessary in the spray tank. For II, a concentrate is prepared by adding the pentachlorophenol to the oil, agitating until dissolved, then adding the wetting agent and mixing until a uniform solution is obtained. In preparing the spray emulsion, add the required concentrate to the spray tank, add an equal volume of water, and agitate thoroughly. This should give a thick, white emulsion that can be diluted out to field strength rapidly with agitation.

Using either formula I or II, the fortified oil can be used at different volume rates in making up the spray emulsion, depending on the succulence of the weeds being treated. The rates given are for average California conditions. Small, succulent weeds require less of the toxic materials; old, tough weeds require more.

There are a number of pentachlorophenol formulations on the market, varying widely in amount of active ingredient. In using these, the grower should try to include 4 pounds of pentachlorophenol per 100 gallons of spray. The total oil content should be 8 gallons or more, depending upon the amount of grasses present among the weeds being treated.

2,4-D selectives

First introduced commercially in California in 1946, for use on rice and small grains, 2,4-D is now being widely used for control of broad-leaved annual weeds, such as mustard, radish, and fiddleneck in small grains, and water plantain and arrowhead lily in rice. It is also used on morning-glory and star thistle in barley, morning-glory, kelp, pigweed, and jimson weed in milo, and on many broad-leaved weeds, including the above, in corn. In addition, weeds in strawberries and flax are being controlled by 2,4-D, as

are many brushy species of weeds on range land.

Most of the applications of 2,4-D have been made as sprays. Dusts have been used to a limited extent, but they are hazardous to neighboring crops because of drift, and the Civil Aeronautics Authority has prohibited applications of 2,4-D dust by plane.

Dosages of 2,4-D are usually given on the acid-equivalent basis. The acid equivalent of a 2,4-D compound is the weight of that compound containing the same



amount of the 2,4-D acetate as 1 pound of the 2,4-D acid. It is obtained by dividing 100 by the percentage of 2,4-D acetate in the compound. This percentage is usually given on the container. (For example: The sodium salt of 2,4-D has a molecular weight of 242; the 2,4-D molecular weight is 220. The sodium salt

contains 220×100 , or 91 per cent 2,4-D.
242

Its acid equivalent is obtained by dividing 100 by 91. For the pure sodium salt, it is 1.1; for the monohydrate, 1.2.)

Recently, there has appeared on the market a preparation which is a mixture of 2,4-D and 2,4,5-T (2,4,5-trichloro-

phenoxyacetic acid). This shows promise in the control of woody species, such as blackberry, oaks, buttonwillows, and others.

Adding about 4 gallons of oil per 100 gallons of spray increases the killing power on brushy species.

CAUTIONS FOR USE OF 2,4-D

1. Do not apply 2,4-D salts for weed control in grain until the crop is 6 inches tall and beginning to tiller. Oats and barley have both been injured by treating too early.

2. Do not spray rice when the water is low or off. Keep the water level up until after treatment.

3. Applications must be controlled to prevent drift to susceptible plants. Cot-

ton, tomatoes, melons, black-eye peas, beans, sugar beets, lettuce, and other crops have been injured as a result of careless application.

4. Wash thoroughly all equipment that has been used for applying 2,4-D, before it is used for other sprays. Crops have been injured by 2,4-D residue in spray tanks. Wash equipment with alkaline solutions such as sodium phosphate, sodium carbonate (sal soda), or household ammonia, for removal of 2,4-D salts. For removal of 2,4-D esters, kerosene or oil emulsion may be used.

5. Residues of 2,4-D will sterilize soil. These residues decompose most rapidly in warm, moist soil. Leaching soil will rid it of residues.

Grass killers

Three chemicals have proved effective as herbicides where grassy weeds are involved.

Isopropyl-N-phenyl carbamate (I.P.C.) is being used to control winter annuals and bunch grasses in ladino clover and alfalfa pastures. It is used at rates of from 2 to 5 pounds per acre, and must be applied so that it can be washed into the soil by rains or irrigation water. Absorbed from the soil, it kills grasses at concentrations that do not seriously injure the pasture crops.

This chemical is not very soluble in water. Some commercial preparations come in the form of wettable powders, others, as emulsion concentrates. These may be applied in suspension in water, if sufficient water is used, if the suspension is kept well agitated, and if the spray pressure is around 100 pounds. Do not attempt low-volume application of the suspension.

Trichloroacetic Acid (T.C.A.). The sodium salt of this acid is approximately neutral, but the ammonium salt is acid and corrosive. Read and follow the directions on the label carefully. Both the

sodium and the ammonium salts are being used to control perennial grasses. These materials are effective either as sprays or as soil treatments. Experiments indicate that a spray treatment which is followed by rains that wash the chemical into the soil may be the most effective. There is some indication that after spraying, the chemical is translocated into the underground rhizomes of Johnsongrass.

On perennials, trichloroacetates are effective at rates of from 20 to 100 pounds per acre, depending upon the species of grass and the vigor of its underground root system. Spray applications at rates around 5 pounds per acre seem promising for controlling watergrass in cotton and sugar beets, but tests have not been extensive enough to warrant a general recommendation at present.

Phenyl mercuric acetate, sold under the trade name of TAT-C-Lect crabgrass killer, is proving effective in the control of crabgrass in lawns. Applied as a spray at rates of from $\frac{1}{2}$ to 2 ounces per gallon per 75 square feet, this material slowly injures the weed and brings about a decline that results in death.

Though the lawn may look somewhat yellow immediately after application, the grass will soon recover and have its normal color. Dosage depends primarily upon the grass— $\frac{1}{2}$ ounce of concentrate per gallon per 75 square feet is used on bentgrass, 1 ounce on bluegrass, and 2 ounces on Bermudagrass. Because the concentration in turn determines rate and extent of killing, more treatments will be needed on bentgrass and fewer on bluegrass and Bermudagrass. Treatments are repeated every 7 days on crabgrass seedlings, every 5 days on older crabgrass plants. The dosage is raised 50 per cent for the third and following treatments. During the treatments, the mower should be set high ($2\frac{1}{2}$ inches) and watering should be resumed 24 hours after treatment. Crabgrass is most easily killed in the small seedling stage, but if treatment is given too early, more seeds will germinate later, and another treatment will be required.

Other phenyl mercuric compounds are now available for crabgrass control. All

of them are poisonous to humans and animals, and should be handled with the greatest caution. When used according to directions, these compounds will kill crabgrass without serious injury to turf.

CAUTIONS FOR USE OF GRASS KILLERS

1. Isopropyl-N-phenyl carbamate is not very soluble in water. Some commercial preparations come in the form of wet-table powders. These may be applied in suspension provided enough water is used, the suspension is kept well agitated, and the spray pressure is around 100 pounds. Do not attempt low-volume application of the suspension.

2. Trichloroacetic acid is a strong acid. Its sodium salt is approximately neutral, but the ammonium salt is acid and corrosive. Follow all precautions printed on the labels.

3. Phenyl mercury compounds are poisonous. Do not leave solution or empty containers around where children or pets have access to them. Follow all precautions printed on the labels.

Application of selective herbicides

Airplane application of selective sprays is becoming standard practice in California. Where the conditions permit (suitable terrain, size of fields, etc.), plane application provides a maximum of speed and convenience, and can be made on wet soils, across fences and ditches, and over rough ground. The crop is not trampled or crushed, and no wheel marks are left in the field. Because of the speed of application (up to 400 acres or more per day, per plane), the spray may be applied when conditions are at their best, whereas ground spraying takes longer and conditions may change appreciably. Low-volume application (5 gal. per acre with water; as low as $\frac{1}{2}$ gal. per acre with oil) makes it possible to treat a larger area per plane load. It also cuts down the cost of application. The

greatest drawback to airplane spraying is the danger of the chemical's drifting to other crops which may be injured by it. Drift can be kept to a minimum through control of volume, and by care on the part of the plane operator.

Ground application of selective dusts and low-volume sprays is also becoming popular and this newer method, because of its economy, is gradually replacing the older, high-volume treatments. At present, there are many machines of proper design to make low-volume applications at accurately controlled dosages and with uniform distribution.

Low-volume application of 2,4-D has been very successful. Following effective use of 2,4-D dusts as selective herbicides in cereals (summer, 1946),

and the application of volumes as low as 10 gallons, by plane, trials with 2,4-D solutions at as low as 1 or 2 gallons per acre were successful provided distribution was even and thorough.

Where oil is used as a low-volume carrier for 2,4-D, diesel fuel and similar oils of medium toxicity seem satisfactory, since only $\frac{1}{2}$ gallon to 1 gallon per acre is required. Where oil is used in greater volume in selective spraying, an oil of low toxicity is recommended, such as automotive diesel oil.

Drift is a serious problem in all dust and low-volume liquid applications of selective herbicides. Much damage has resulted from uncontrolled application of such materials, especially by airplane. To prevent such damage, the spray operator should know the location of all sensitive crop plants and should take every precaution to keep the spray in the field being treated.

Spray equipment. Construction and operation of spray equipment is discussed in California Agricultural Experiment Station Circular 389, "Chemical Weed Control Equipment." This circular describes nozzles, pumps, tanks, arrangement of booms, and means for calibrating sprayers at different ground speeds with varying orifice sizes, nozzle spacings, and pressures.

Spray pressures. Pressures of from 75 to 125 pounds per square inch are adequate for applying dinitro selectives and oils. Pressures from 10 pounds to several hundred pounds are being tested in low-volume application of 2,4-D. Only time and experience will prove which are best. Satisfactory results were obtained on plots where 5 and 8 gallons per acre were applied, with small-orifice nozzles and around 50 pounds pressure.

Effects of weather. Where dinitro selectives are being used on peas and flax, the plants should not be sprayed when wet with dew, fog, or rain, or when the humidity is very high. Increased wetting of the crop under these conditions may result in serious injury. When dews are heavy in the evening, lasting into the morning, limit spraying to midday.

With oils, moisture on the plants is less serious. The spray usually blows off most of the water, and oil will wet the waxy cuticle of plants even if a thin film of moisture is left. With 2,4-D, excessive moisture on the plants at the time of application may dilute the spray and lower its effectiveness. Rainfall a few hours after 2,4-D spraying may not impair results, particularly when susceptible plants such as wild mustard and radish are being treated. Warm weather tends to hasten absorption of 2,4-D.

State of growth. Remember:
Young weeds are easiest to kill. But the principal drawback to early spraying is that some weed seeds may germinate after the spray treatment and bring about reinfestation. This is not a serious problem in cereal crops because the crop is sufficiently developed before reinfestation so that it can compete successfully with the weeds. In onions, carrots, milo, and other truck and field crops that are intertilled or planted less densely, however, this may be a real problem. A possible answer is a combination of a pre-emergence spray with one or more selectives.

In addition to the selective herbicides discussed in this circular, there are other organic compounds, some of a hormonal nature, which are being tested. It may safely be predicted that as the years go by, a number of selective chemicals for specific purposes will become available.

In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.